REQUIRED IN-HOUSE CAPABILITIES FOR DEPARTMENT OF DEFENSE RESEARCH, DEVELOPMENT, TEST AND EVALUATION

1 OCTOBER 1980

Research Office
Office of the Under Secretary of Defense
for Research and Engineering

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A094 024	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Required In-house Capabilities For Department of Defense Research, Development, Test and Evaluation		5. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Office of the Under Secretary of Defense for Research and Engineering (Research and Advanced Technology) Research Office, The Pentagon Washington, DC 20301 4/21		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS (11)		12. REPORT DATE 1 October 1980
		13. NUMBER OF PAGES (12) 26
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for Public Release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Department of Defense	R&D Required Capabilities
Research and Development	In-house R&D
R&D Management	Government R&D
DOD's R&D	R&D Process
DOD's RDT&E	R&D Environment

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes the required in-house RDT&E capabilities of the Department of Defense (DOD) RDT&E organizations. It discusses the role of Government R&D, the R&D process and environment, DOD responsibilities, and finally the required in-house capabilities. This document discusses the responsibilities of the DOD internal research, development, test and evaluation establishment, which comprises program management offices, laboratories, research and development centers, test and evaluation activities,

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and other technical organizations. Collectively, these internal RDT&E organizations represent a vital component of the Defense research, development, and acquisition program.

19. DOD's R&D Responsibilities
R&D Centers
Laboratories
Required In-house Capabilities
R&D Acquisition
R&D Requirements
R&D Technical Organizations
System Acquisition
Technology Base
Engineering Development
Project Management
Test & Evaluation

THE UNDER SECRETARY OF DEFENSE

WASHINGTON, D.C. 20301

RESEARCH AND
ENGINEERING

1 OCT 1980

MEMORANDUM FOR ASSISTANT SECRETARY OF THE ARMY (RESEARCH, DEVELOPMENT, AND ACQUISITION)
ASSISTANT SECRETARY OF THE NAVY (RESEARCH, ENGINEERING, AND SYSTEMS)
ASSISTANT SECRETARY OF THE AIR FORCE (RESEARCH, DEVELOPMENT, AND LOGISTICS)

SUBJECT: Required In-House Capabilities for DoD's RDT&E

My goal in utilizing resources for the conduct of Defense research and development programs is to take maximum advantage of all Government, industry, and academic sources to develop the best possible systems and equipment to support our Defense needs. Our in-house technical organizations perform a special role which can best be described as providing the leadership in carrying out these programs. The attached document provides a general description of the required capabilities of DoD technical organizations in performing this leadership function. It is based on a study conducted by the Office of the Deputy Under Secretary of Defense for Research and Engineering (Research and Advanced Technology) with participation by the Army, Navy, and Air Force.

Each Military Service develops and utilizes specific capabilities in its technical organizations to satisfy its specific mission requirements. These capabilities will vary in degree and size among the Military Services as well as among different R&D programs, and they can be expected to change in time. This document represents a general expression of the DoD policy concerning R&D and should provide useful planning guidance and support for these organizations.

I would appreciate it if you would provide appropriate internal distribution, including all RDT&E organizations.

William J. Perry

Attachment

FOREWORD

This report describes the required in-house RDT&E capabilities of the Department of Defense (DOD) RDT&E organizations. It discusses the role of Government R&D, the R&D process and environment, DOD responsibilities, and finally the required in-house capabilities.

This report has been produced by the Office of the Director for Research, OUSDRE (R&AT), with inputs from the Office of the Secretaries of the Army, Navy, and Air Force. Special thanks go to Mr. James Spates, Dr. James Probus and Dr. Bernard Kulp, and particularly to Mr. Earl Langenbeck, who put the report together.

TABLE OF CONTENTS

INTRODUCTION

This document discusses the responsibilities of the Department of Defense (DOD) internal research, development, test and evaluation (RDT&E) establishment, which comprises program management offices, laboratories, research and development centers, test and evaluation activities, and other technical organizations. For brevity, these elements of DOD's RDT&E establishment will be referred to in this document as RDT&E organizations.

Collectively, RDT&E organizations represent a vital component of the Defense research, development, and acquisition program. They employ 60,000 people and have a total annual budget of approximately five billion dollars.

These RDT&E organizations, each with assigned missions in specific fields of science and technology, systems development, or acquisition support, constitute a diverse mix of RDT&E capabilities tailored to the needs of each Military Service. Together, however, they share a common responsibility: that of sustaining the technological strength of the Department of Defense in safeguarding the national security. This document describes the capabilities of these RDT&E organizations--capabilities they must continue to have in order to meet that fundamental responsibility.

GOVERNMENT R&D

Federally supported research and development programs serve public purposes considered by the President and the Congress to be of national importance. Research and Development refers to all scientific, engineering, and technical efforts, including test and evaluation, which are directed toward acquiring new knowledge, applying existing knowledge to new uses, or improving on existing applications. The results of these efforts are intended to support the ultimate production of useful materials, devices, systems, or methods, including the design and development of prototypes and processes. Agencies of the federal government support mission-oriented R&D efforts primarily to obtain the knowledge and information necessary to make investment decisions involving the expenditure of public funds for the acquisition of material resources, and to provide the disciplines in the systems acquisition process to assure that the government obtains a product that satisfies the requirement.

Two fundamental tenets determine the government's approach to the management of R&D programs. The first is that the decision-making process leading to material acquisition is inherently a governmental function. Management and control of federal research and development programs must therefore remain firmly in the hands of government officials clearly responsible to the President and the Congress.

Equally as fundamental to government R&D is the policy that the government shall rely to a large degree on the private sector to supply its needs. This policy is not only a philosophical endorsement of private sector participation, it is also an expression of the government's obligation to operate efficiently and effectively by benefiting from the incentives in the nation's competitive system of free enterprise.

The proper role of research and development performed within the government is in consonance with and fully supports these two fundamental tenents. The complexities of acquisition decisions, which require the application of sound scientific and technical judgments, dictate that the government maintain a strong internal competence in research and development. This competence both facilitates government decision making and stimulates equitable competition among private sector elements seeking to market services and products to the government. In short, in-house R&D competence permits the government to function as a "smart buyer" in a technically sophisticated marketplace.

In carrying out the acquisition function, the government must often choose among alternatives presented by industrial producers, each of whom understandably advocates his particular product. This advocacy role is largely motivated by the producer's commercial, profit-making interests. The governmental function of selecting among technical alternatives requires internal technical capability of sufficient breadth, depth, and continuity to assure that the public interest is served. The nature of this technical capability is dictated largely by the degree of complexity and sophistication of the material to be acquired. It is widely acknowledged that such capability can only be sustained through continued, direct participation in all phases of R&D by government technical organizations.

R&D is therefore an integral part of a government agency's public responsibilities; an agency would be seriously failing in these responsibilities if it were forced to rely solely on the technical judgments of the private sector in making acquisition decisions.

Finally, a strong government technical capability promotes greater and more equitable competition among potential private sector performers seeking to market services and products, by assuring that the government can and will function as a smart buyer. Additionally, transfer of technology from government to the private sector can result in significantly improved R&D products to the government.

THE R&D PROCESS AND ENVIRONMENT

It is appropriate at this point to discuss the nature of the R&D process, and to examine the general nature of government technical organizations in terms of the institutional aspects, qualities, and characteristics they must possess to fulfill their R&D role. This discussion will serve to clarify the specific technical efforts pursued within the Department of Defense R&D establishment.

By its very nature, R&D is a long-term process, deriving from fundamental knowledge and evolving to specific applications and useful products. The R&D process demands the intricate interaction of many factors over significant periods of time, typically many years, to produce results. Training of technical personnel, acquisition of facilities, and development of requisite mature judgment are the time-consuming and expensive elements undergirding an effective R&D capability. Research and development must not, therefore, be placed into competition with short-term economic priorities. Rather, R&D competence must be maintained by a continuous, long-term commitment that is integral to the overall acquisition process. A closely related requirement is that the government technical organization serve as part of the agency's corporate memory of these long-term efforts. This corporate memory is the technical organization's collective understanding and knowledge acquired over time through direct, "hands-on" experience by its own direct participation in R&D, its experience as contract manager of R&D contracts, and its experience as the user of the results of both government-sponsored and private sector R&D. Corporate memory is itself a valuable and unique agency resource. It includes not only knowledge of previous successes and failures, but also insight and understanding of the total R&D process. As such, it cannot be simply cataloged for the record, since it is both factual and judgmental.

The R&D process is synergistic in nature. Scientists, engineers, technicians, and support personnel all contribute to and are essential parts of the process. Also involved is the synergistic combination of university, industrial, and government activities working to bring the proper talents together in roles that will assure the successful application and output of the nation's R&D endeavor. Most government-performed R&D is accomplished in partnership with the private sector, both commercial and academic. It is not unusual for R&D programs to be performed both intramurally and extramurally in such a manner as to strengthen the private sector's technical capabilities while preserving the government's leadership role. The salient point is that the effective performance of R&D by government requires that the government R&D manager have the ability to marshall those performers that his judgment dictates are necessary to attack and resolve the problem at hand.

The environment in which R&D is conducted contributes significantly to its effectiveness. The elements of that environment are numerous, spanning a broad spectrum of technical expertise. It follows, therefore, that the healthy R&D environment will provide the manager with ready access to a coherent and integrated mix of the talents required. Long-term stability is another important asset to the R&D environment. It is therefore necessary to maintain the stability of the government R&D institution, i.e., the RDT&E organizations. Significant fluctuations in funding levels, personnel, and facilities must be avoided if the government laboratories are to fulfill their vital missions. Flexibility is another significant characteristic of the R&D environment. The technical direction a program will take is often unknown. What at first appears to be a mechanical problem may become one of electronics or materials as the work progresses. Requirements cannot be stated *a priori*, because part of the R&D process is learning what the requirements can or should be. The government R&D manager must have the flexibility to replan and to reconfigure the resources applied to a particular task as the work progresses.

A significant feature of DOD technical organizations which contributes substantially to a healthy working environment is the clear orientation toward the eventual useful application of the results of their technical efforts. This feature is strengthened by continued, direct association and interaction with the ultimate user: the operational military forces. The appreciation of both present and anticipated military problems which this relationship provides DOD technical organizations is essential to assuring a productive R&D and material acquisition establishment.

Another characteristic of R&D, particularly DOD-sponsored R&D, is the broad scope of involvement from basic research through full-scale development, into production and user support of sophisticated systems. It becomes necessary, therefore, for DOD to conduct activities throughout the R&D spectrum. This calls for differences in approaches to the conduct of research and development, the respective roles of the various performers, and the management philosophies employed. R&D is not an enterprise conducted with standard operating procedures. This is particularly true for DOD technical organizations, whose responsibilities include serving both short-term and long-term defense needs. These responsibilities require that a full spectrum capability be maintained to engage in a broad range of scientific and technical efforts, representative of all those which DOD supports. This does not necessarily mean that each organization must be expert in every technical field and in every phase of the R&D process. But collectively, the DOD R&D establishment must possess up-to-date expertise which can be brought to bear on the full spectrum of Defense needs and problems.

Finally, the R&D process is characterized by uncertainty. One cannot always say with certainty that a particular problem will be solved. Indeed, some observers believe a primary role for government R&D is the systematic and progressive reduction of uncertainties as concepts move from research toward application. In R&D, as in some other activites with uncertain outcomes, the major considerations in the decision process do not depend entirely on cost. The quality of the product, the likelihood of success, past performance, the availability of key personnel, the soundness of approach, all these and more become the relevant criteria for decisions in the R&D process.

As components of the Defense Department, DOD technical organizations possess and demonstrate an institutional perspective toward their responsibilities and to overall national security objectives. Unlike the private sector organizations, whose primary interests are quite properly profit motivated, the interests of these organizations are those of the Defense Department. Institutional perspective and dedication to national purposes are desirable and valuable attributes of the DOD technical organizations, and are indicative of their service to the public interest.

DOD RESPONSIBILITIES

The function DOD provides, the safeguarding of national security, is paramount over all other governmental responsibilities. The Department seeks to meet its responsibilities in an environment of uncertainty and rapid change brought on by the continuing threat of a dedicated adversary in the world community. DOD sponsors research, development, test and evaluation as a means toward acquiring the knowledge and material resources with which to carry out its functions. As a necessary part of its sponsorship, DOD must maintain an active internal, direct involvement in RDT&E. The sheer size of the total Department of Defense RDT&E effort, together with the value of the procurements based in whole or in part upon technical judgments, calls for examination and discussion of DOD's requirements for internal technical capability. DOD RDT&E efforts constitute about one-half the total federal R&D expenditures. Procurement decisions based upon these R&D efforts account for many additional billions of dollars.

The primary obligation incumbent upon DOD's internal technical capability is that, collectively, it must maintain the necessary competence to assess the progress and the results of government-sponsored R&D and independent research and development (IR&D) conducted by the private sector. The knowledge and information generated by research and development is a form of advice. The government must ensure that outside technical advice does not become *de facto* decision-making, and that the decision-making process remains solely a function of government. The major portion of Defense RDT&E is conducted by the private sector, which is also the primary supplier of the material resources acquired and used by the Defense Department. A DOD internal technical capability is required to ensure that government material acquisition decisions are based on sound technical judgments, in short, to enable the government to function as a smart buyer in a technically sophisticated marketplace.

This primary responsibility of the DOD technical organizations could be viewed as solely an advisory role--that of providing unbiased, objective technical advice and recommendations as needed for higher level decision-making. But such a role would be largely one of a passive, outside observer of science and technology. The rapid pace of technological developments, continually changing operational requirements, the scope of RDT&E-based procurements, and the technical sophistication of the marketplace in which these procurements occur, dictate a more active role. The quality of any DOD RDT&E organization depends on the current technical competence and breadth of experience of its people. These qualities can only be developed and maintained through the continued, direct involvement of those people in the research and development process itself. For example, the technical accuracy of an organization's findings--even if they are only

advisory in nature--must be substantiated and supported by appropriate conceptual studies, engineering analyses, experimentation, development, and feasibility demonstrations. Without such participation, an organization quickly loses its capacity to function effectively.

The Defense Department's internal technical capability, in the form of its R&D organizations, is also required to provide an institutional perspective and continuity not available from any other source. Each RDT&E organization, as an integral component of the Defense Department, offers continuity of experience within the range of its respective mission. This continuity, or corporate memory, enables an RDT&E organization to view--and pursue--its responsibilities from a broad institutional perspective, with a perception of how military capabilities have developed over time, of the usefulness of existing capabilities, and of future needs with access to intelligence information. As stated in the final report of the Commission on Government Procurement, "...a strong internal capability must be judiciously maintained in order that the Government can itself properly address the question of what its needs are. [This] capability to pursue a wide-ranging RDT&E program...is essential to the maintenance of a proper defense capability."[1] With this perspective, Defense Department RDT&E organizations can make substantial contributions to defense planning, both by responding to stated military requirements and by recognizing and exploiting technological opportunities.

The foremost capability requirement is for a staff of trained and experienced technical people with up-to-date knowledge in all fields of science and engineering. Technical support functions, too, contribute to the agency's objectives. Depending on the nature of these objectives, this capability may extend from theoretical scientific investigations through the rigorous engineering disciplines in the physical, life, behavioral and social sciences.

Knowledgable scientists, engineers, and technical support personnel remain knowledgable only so long as they continue to participate directly in their respective fields. This is true not only for persons as individuals skilled in technical specialties, but also collectively for organizations. Because of the intrinsically uncertain nature of RDT&E, decisions concerning the level of internal technical competence needed within an agency and the nature of the effort necessary to maintain that competence must remain matters of executive management judgment, to be exercised within the bounds of the agency's duly established responsibilities and the public resources provided to meet those responsibilities.

[1] Report of the Commission on Government Procurement, Volume 2, Washington, D.C., December 1972.

REQUIRED IN-HOUSE CAPABILITIES

The general requirements for an internal RDT&E capability have resulted in specific in-house involvement at varying levels in all phases of the RDT&E process, from basic research and definition of operational requirements, through systems development, to engineering support of deployed operational weapons systems. Essentially, the Department of Defense requires some internal RDT&E capability in every phase of the RDT&E process in each of its mission areas. The level of in-house involvement varies in each phase and in each mission area depending on a variety of factors.

Management of each phase within each mission area must remain under the control of DOD, irrespective of where the actual work is accomplished, to ensure that the various phases of RDT&E programs are orchestrated such that they will result in effective, timely, and cost-effective military systems. RDT&E effort within DOD falls generally into the categories described herein.

I. MAJOR FUNCTIONS

1. BASIC RESEARCH

Basic research is scientific study and experimentation directed toward increasing knowledge and understanding in those fields of the physical, engineering, environmental, biological-medical, and behavioral-social sciences directly related to explicitly stated, long-term national security needs.

Basic research stimulates original work and increases competence in all fields of technology relevent to identified military problems. It also serves as part of the base for subsequent exploratory and advanced developments in defense-related technologies, as well as for new and improved military functional capabilities in areas such as communications, detection, tracking, surveillance, propulsion, mobility, guidance and control, navigation, energy conversion, materials and structures, and personnel support.

2. APPLIED RESEARCH (EXPLORATORY DEVELOPMENT)

Applied research (exploratory development) includes all effort directed toward the solution of broadly defined problems, short of major development programs, with a view to developing and evaluating technical feasibility. This type of effort may vary from fairly fundamental applied research to major subsystems. It would thus include studies, investigations, and minor development effort. The dominant

characteristic of this category of DOD-supported effort is that it is directed toward specific military problem areas with the goal of developing and evaluating the feasibility and practicability of proposed solutions and determining their parameters.

Applied research is frequently the first step in moving new scientific discoveries into applications of value to DOD. Applied research is oriented toward seeking solutions to specific technical problems. It is therefore vital that DOD maintain an applied research capability to: address critical problems whch require substantial technical insight; objectively measure the practical value of new scientific discoveries for application to military needs; and assess the value of technological innovations proposed by the private sector. Evaluations made at an early level of development tend to avoid the wasted time and cost incurred when problems are not discovered and resolved until the later stages of development.

3. ADVANCED DEVELOPMENT

Advanced development includes all projects that have moved into the development of hardware for experimental or operational tests. The prime result of advance development is proof of design concept rather than the development of hardware for service use. Projects in this category have a potential military application. Advanced development is the systematic application of knowledge toward the production of useful materials, devices, and systems or methods. Included in this category are the design, development, and improvement of prototypes and processes to meet specific functional or economic requirements.

The principal reason for maintaining advanced development capabilities within DOD is to link state-of-the-art technology with contemporary military problems, based on full knowledge of previous, related endeavors.

4. ASSESSMENT OF SCIENCE AND TECHNOLOGY BASE

Assessment of science and technology base involves the continuing monitoring, assessment, and evaluation of current science and technology in terms of potential for military utilization.

In order to commit government resources to the most effective courses of action, DOD must be able to assess the availability of appropriate technology to meet specific needs, determine the risk involved in various technological options, and the time required to meet certain goals. This capability is critical to achieving and maintaining the technological advantage necessary to offset the numerical advantage of potential adversaries, and to controlling effectively the export of critical technology.

5. MISSION ANALYSIS

Mission analysis, although not a primary responsibility of RDT&E organizations, does involve technical analysis and evaluation relevant to the Agency's mission, goals, and objectives in order to identify generic RDT&E program and system acquisition needs. This aspect of mission analysis provides the mechanisms for identification of systems needs and deficiencies, both current and future, and determination of preferred courses of action.

6. CONCEPT EXPLORATION AND SYSTEM DEMONSTRATION/VALIDATION

Concept exploration is the feasibility study, development, and refinement of system concepts in response to military needs. Closely associated with concept exploration is the demonstration and validation phase, during which hardware and software to implement the selected technical approaches are designed, fabricated, tested, and evaluated in comparison to alternate concepts.

These closely allied phases of RDT&E, concept exploration and system demonstration/validation, are critical to the selection of those systems technical approaches that most effectively meet the criteria of military utility, worth, and cost effectiveness throughout the life cycle.

7. FULL-SCALE ENGINEERING DEVELOPMENT

During the full-scale engineering development phase, hardware is engineered for service use prior to approval for procurement for operational use. The system, including supporting equipment and documentation, is designed, manufactured, and tested. Programs and projects in engineering development are directed toward specific, approved military needs.

Products undergoing full-scale engineering development are reviewed for technical adequacy to satisfy design objectives and specifications, to insure that they are of suitable quality for operational use, and to solve any system problems that arise.

8. ENGINEERING IN SUPPORT OF PRODUCTION

Engineering in support of production encompasses the periodic testing of production hardware; the analysis of failures; the establishment of corrective actions; the authoritative control of all technical documentation; and the review of proposed production changes, including impact on cost, performance, producibility, quality assurance, and safety.

Engineering support during the production phase of complex systems is essential to ensure that problems encountered in procurement, manufacture, and military use are resolved without degradation of performance, reliability, or safety. Throughout production, capability must be sustained to evaluate production and usage failures, assess proposed changes, and control the production baseline.

9. TEST AND EVALUATION

The test and evaluation phase entails a series of events which demonstrate whether a system meets established performance objectives prior to release to production. These events include performance and monitoring of laboratory and field tests in accordance with a master test and evaluation plan, analysis of test data, and evaluation of test results.

Test and evaluation measures program accomplishments as compared to program objectives, thereby providing the rationale for management decisions regarding continued expenditure of public funds. Military systems, once acquired, require continued effort in the development of tactics, operator training, and readiness. Test and evaluation determines whether system operability justifies continued expenditure of public resources.

10. MAJOR RDT&E FACILITIES

Major RDT&E facilities are provided by DOD to meet specific needs unique to national defense requirements. The private sector generally does not provide these specialized facilities due to such factors as large capital investments, extensive land, air and sea space required, etc., coupled with the economic risk of inadequate return on investment. From a practical standpoint, the costs involved preclude competition within the private sector.

These RDT&E facilities form an important segment of DOD's internal technical capability. DOD is responsible for the management, operation, and maintenance of its RDT&E facilities, although these functions are not necessarily performed exclusively by in-house employees. Further, the results of efforts performed in specialized RDT&E, and often the use of the facilities, are shared with the private sector.

11. USER SERVICES AND SUPPORT TO OPERATING FORCES, INCLUDING PRODUCT IMPROVEMENT

User services and support to operating forces include technical functions necessary to support the military user from the time a system (or equipment) is accepted for service use until it is no longer operational. Such technical services and support include installation and testing; correction of deficiencies of design; system improvements or retrofits; logistic support; training; and assistance in the development of tactics. Many of the in-service support functions directly affect military operational readiness and ability to perform assigned missions.

II. SUPPORTING RESPONSIBILITIES

The eleven items above identify major RDT&E categories. The following items identify representative responsibilities and special functions that must be performed in varying degree to support the primary RDT&E areas. This portion of the document provides a different view of Defense RDT&E. This listing and discussion is by no means all-inclusive. In most cases the items discussed span two or more of the major categories of Defense RDT&E discussed above. It is another way of looking at the required in-house capabilities.

a. Smart Buyer

The complexity of RDT&E, encompassing the involvement of many performers and the resultant interfaces throughout the life cycle, places heavy demands on DOD to realize the maximum value on investment. DOD relies on in-house technical organizations to exercise a "smart buyer" role in support of acquisition and assistance. This capability is maintained in-house through in-depth experience and hands-on participation of a cadre of multi-discipline specialists.

The smart buyer concept recognizes the ability of the private sector to conceive, demonstrate, and develop military hardware. Through controlled competition and informed analysis, the smart buyer avoids costly duplication of effort and reduces development, procurement, logistics, and support costs.

The in-house smart buyer capability provides functions such as: system concept evaluation; functional specification preparation; source selection; technical contract monitoring; technical direction; design reviews; systems engineering; test and evaluation; and Independent Research and Development evaluation.

b. RDT&E Program/Project Management

Effective management of both business and technical aspects is essential to the efficient development of military hardware systems and interrelated capabilities. In-house organizations must perform the functions of program/project management. Typically these functions are performed by major headquarters organizations, but all or part of this responsibility is sometimes delegated to field R&D organizations.

DOD in-house organizations must prepare the necessary program documents (e.g., Decision Coordinating Paper (DCP), Mission Element Need Statement (MENS), Test Evaluation Master Plan (TEMP), Integrated Program Summary (IPS)); interface with and provide reports to higher authority; award, direct and monitor contracts; exercise financial management (preparing budgets, allocating funds, monitoring expenditures) and administer block funding; and coordinate in-house technical effort.

The utilization of the in-house organizations makes it possible to exercise prudent management control over DOD's RDT&E responsibilities. In addition, in-house activities greatly assist the program/project managers by providing independent assessments of hardware performance and technical risk.

c. Technical Intelligence Assessment

Assessments of scientific and technical intelligence are directed toward the avoidance of technological surprise and the identification of promising new lines of technical development. These assessments involve sensitive information and have the potential for significant impact on DOD policy and RDT&E programs. To be of use to the government, these assessments must be made in the context of a broad spectrum of technology, current DOD operational capabilities and limitations, and responsiveness to DOD mission requirements.

Technological surprise can have devastating consequences for the defense posture of the United States. Only a close and continuous working relationship between the intelligence community and the in-house technical community can avoid the hazards of technological surprise.

Similarly, identification of promising new lines of technical development by assessing foreign developments is an important part of DOD's responsibility for the maintenance of technological superiority.

d. Provide Options for Future Systems

Government in-house RDT&E organizations, as a part of their assigned missions, are required to provide options for future military systems. These RDT&E organizations are uniquely situated because of their continuing interface

with the users of military systems in operation, the buyers and producers of systems, and the world of science and technology. Through the identification of current and future deficiencies, assessment of science and technology, and as the technical corporate memory, the DOD RDT&E organizations not only propose options for future systems, but also participate in the evaluation of system concepts proposed by others.

The government in-house RDT&E organizations have no vested interest in the production, the profits from production, or the commercial sales spin-off of a specific option or set of equipments. This places the DOD RDT&E organizations in a better position of objectivity in making evaluations and recommendations.

e. RDT&E in Areas of Limited Industrial or Academic Interest

Many RDT&E areas of military importance are of limited interest in the private sector because of the highly specialized nature of the technologies involved and the limited opportunities for commercial profit.

The DOD RDT&E organizations play a critically important role in such areas by providing:

- technical expertise for the military planning process and the development of military systems.
- specialized test facilities unavailable elsewhere.
- in-service engineering support to the operating forces throughout the service life of operational systems.
- defense contractor access to pertinent data.
- wide access to and familiarity with Military Service needs and problems.
- repository of the DOD technological corporate memory.

f. Exploitation of New Technological Opportunities

The rapid identification and exploitation of new technological opportunities is a part of the DOD in-house capability. Defense technology expands rapidly, and the balance of power is sensitive to the emergence of new technologies. Identification of those technologies having the highest payoff to DOD's mission is vital to the national security. Identifying and pursuing inappropriate or obsolescent technologies, on the other hand, can waste valuable and limited resources. Hence DOD maintains an in-house capability in this area--specifically, a capability both knowledgable in the technical state-of-the-art and sensitive to DOD's mission requirements.

The continued assurance of technological superiority in defense systems is a high DOD priority. Responsibilities in this area can neither be delegated nor diluted. Maintenance of technological superiority requires DOD to set the national pace in defense-related technology, and to be sufficiently knowledgable in all facets of those technologies (from research to engineering) to be a smart buyer. This requires a basic capability in each defense-critical technology.

g. Understanding of and Interaction with the Military User

The military user, because of the dramatic increase in the technical sophistication of weapon systems, frequently requires technical guidance on their use, especially when deploying new weapons or considering rapidly changing threats. Conversely, the successful accomplishment of RDT&E programs implies an essential need for an in-depth knowledge of aspects of warfare such as tactics, environmental considerations, hardware capabilities, and personnel motivation. Experience has shown that the professional personnel of in-house RDT&E organizations are uniquely positioned to acquire knowledge of the operational utility of weapon systems through continued, direct contact with the military user. In some areas, RDT&E laboratory support is provided to operational commanders by small groups of senior scientists and engineers with broad technical backgrounds who represent the laboratory "corporation" and are temporarily assigned as advisors to operational staffs. These individuals "live" with the operational forces, observe day-to-day operations, evaluate weapon system effectiveness and its impact on tactics, identify system problems or deficiencies, and recommend corrective actions. Corrective actions include, for example, recommendations to (a) develop new weapon systems; (b) improve existing products; (c) tactically employ a system in a different scenario; or, (d) improve system training, maintenance or operability. Recommendations are communicated directly to in-house RDT&E laboratory management. Advice to the tactical commander can generally be characterized as being needed immediately, positive in tone, and keyed to a specific plan of action that quickly improves his combat capability.

h. IR&D Program Evaluation

Congress has charged DOD and NASA with the evaluation of industrial Independent Research and Development (IR&D) projects (P. L. 91-441, Sec. 203). IR&D programs of 69 major defense contractors whose total IR&D expenditures totaled $1.8B were evaluated in 1978. These programs are established independently by contractors and the costs are recovered through indirect cost allocations to customers' contracts. In 1978, about $600M of the incurred costs were allocated to DOD contracts. Meaningful quality and relevant evaluation and exploitation of the IR&D effort depend upon in-house expertise in the technological areas under review.

i. Contractor Proposal and Performance Evaluation

A process of competitive source selection is basic to the acquisition of major military R&D and systems. Selection of those sources that can best meet the needs and requirements of the government depends upon accurate, thorough and impartial evaluation of contractor proposals. Identification and selection of the most promising concepts lead directly to military R&D systems, ability to meet operational requirements and carry out assigned missions, efficient use of funds, savings in time and cost, and concrete data in justification of source selection. DOD in-house RDT&E organizations provide the technical experts and specialists needed for informed, independent evaluations of contractors' technical proposals.

Astute judgment regarding technical alternatives, technical risks, and competing concepts is the indispensable key to management decisions affecting the development and acquisition of expensive military systems. An informed in-house technical capability is the best way to achieve unbiased recommendations and judgments regarding these increasingly sophisticated and expensive systems.

Following the selection of a private-sector source, it is obviously in the government's interest to ensure that the contract requirements for cost, schedule, and performance are met. The in-house organizations provide technical monitoring, guidance, and assistance to the contractor and program manager. This system of checks and balances enables technical problems to be identified at an early stage when they can be resolved with minimum negative impact on the program. The existing in-house capability for preparing test plans, establishing performance requirements, conducting or monitoring tests, analyzing data, and evaluating test results ensures that all critical performance characteristics are tested in an operationally realistic manner and that the test results are interpreted correctly.

j. Provide Quick Reaction to Operational Problems

The technical capability of responding rapidly to emergency situations and trouble-shooting requirements is essential in solving operational problems. A cadre of highly skilled in-house specialists can best respond to situations of this nature. The in-house activities are prepared to respond rapidly to unforeseen situations for which there is insufficient lead time to involve the acquisition process.

k. Interface with Scientific and Engineering Community

DOD must stay abreast of advances in science and technology which could have important military applications. DOD scientists and engineers are able to establish and maintain working relationships with scientists and engineers in colleges and universities, other not-for-profit organizations, technical societies, industry, and foreign scientists and engineers. Through the exchange of scientific and technical information, DOD scientists and engineers help to ensure that technology opportunities are identified and examined for Defense applications. This interchange also supports the requirement to advance the state-of-the-art in areas of interest to DOD.

l. Cooperative R&D with Allies

DOD's in-house RDT&E organizations are the vehicle for coordination of R&D with our NATO and other allies. Through technical information exchange agreements and joint efforts, duplication of R&D is minimized, joint efforts on mutual problems are carried out, and special and unique facilities are shared which thereby provide mutual cost and technical benefits.

m. Integrated Logistics Support

Integrated Logistics Support (ILS) includes the identification and acquisition of all resources necessary to economically and efficiently support a system throughout its life cycle. The major elements of ILS include: maintenance planning; support and test equipment; supply support; packaging, handling, storage, and transportation; management of technical data; personnel and training; facilities; and resource funding. The importance of ILS is evidenced by the fact that logistics support costs for military systems are typically several times greater than the total costs to develop, evaluate, and manufacture the systems.

Development and implementation of a comprehensive ILS program require a thorough understanding of the development process, the role of support activities, and operational considerations. The maximum potential benefit of ILS can only be realized when:

- The ILS program is incorporated into the development process early enough to avoid adverse effects on system performance or program schedule.

- Interaction between the support and design communities is maintained throughout the development program to assure the timely acquisition of necessary support resources.

- ILS concepts are developed to ensure that system readiness is maintained throughout a system's operational life.

Since ILS is a systematic process involving the careful planning, managing, and pulling together of a variety of Defense resources, it is important that it be performed under the control of an in-house technical organization.

n. Reliability and Maintainability

Reliability and maintainability involve those engineering disciplines that assure that weapons systems and equipment will meet the objectives required to satisfy operational readiness. For reliability and maintainability in new systems acquisition, and product improvement, rework/overhaul of older systems, the responsibility must remain within DOD and in each of the Military Departments. This capability consists of:

- Ensuring that the maximum essential and achievable reliability and maintainability requirements (goals and thresholds) are established for the development of new weapons systems.

- Ensuring that reliability criteria are consistent with performance requirements.

- Ensuring that demand is placed on the development laboratories and contractors for reliable design concepts to reduce dependence on logistics support.

- Monitoring reliability design reviews (i.e., preliminary, critical, and preproduction reviews of various phases of weapons systems development).

- Assessing whether the reliability and maintainability efforts carried out by the program/acquisition managers, laboratories, and contractors are satisfactory.

o. Mobilization Requirement

Many of DOD's in-house RDT&E capabilities, functions, and responsibilities can be expected to expand in the event of war, depending upon the particular scenario. For example, in a full-scale war emphasis could be placed on maximizing operational systems readiness, while less emphasis could be placed on

those basic research and exploratory development projects that would not provide new capabilities in time to support the war effort. By maintaining a full spectrum capability, technically qualified manpower is available for diverting to those functions which require greater emphasis, such as providing quick solutions to in-service problems. It is especially important that technical manpower be available for rapid assignment to the field if necessary.

In the event that mobilization requirements for technical manpower exceed in-house capabilities, the available in-house R&D manpower will provide the corporate base to manage an expansion of effort, consisting of increased in-house manpower plus private sector support where appropriate.

p. Producibility

Producibility is a systematic review to assure that a design can be fabricated and tested in a cost effective manner. It includes the selection, or monitoring the selection, of materials, components, tolerances, and manufacturing processes/methods to be used in producing the design. Producibility of the design must be addressed during the design iteration process in order to achieve the desired performance characteristics. Producibility studies are performed to support material selection and manufacturing processes/methods in light of planned production rates, with special emphasis on critical components. The government must be able to evaluate the producibility of system designs to ensure production capabilities and to minimize follow-on costs.

q. Design-to-Cost Management

This discipline seeks to implement the design-to-cost concepts as established by DOD Instruction 5000.28. This instruction requires that the design of weapons to performance parameters includes consideration of cost parameters of both acquisition and ownership. System development must be continuously evaluated against these requirements with the same rigor as that applied to technical system capability, cost, and schedule. Cost control is a governmental responsibility for which in-house design-to-cost management capability must exist.

r. Human Engineering and Manpower Considerations in System Design and Operation

Human Engineering (Crew Systems) involves the application of human characteristics and performance data to the design of the physical part of the man/machine system (displays, controls, formats). Human Engineering ensures that the physical part of the system will conform to man's abilities and limitations and be compatible with the tasks he must perform.

The Human Engineering function deals with the generation of specifications to which weapon systems must be built and supplied to the government. Overall, responsibility for this function should be retained in-house in the acquisition process.

Manpower is a major determinant of every weapon system's life-cycle, costs, and operational effectiveness. Manpower quantities, training demands, skill-level requirements, and maintenance task times are all determined, in large part, by the configuration selected by the design engineer. Failure to identify manpower

implications in the early stages of program development, coupled with rising manpower costs, could lead to the production of systems requiring excessively specialized skills, and could push life-cycle costs far beyond the estimates used in making the production decision. In the concept formulation stage, DOD must be able to evaluate alternative designs, not only in terms of the satisfaction of minimum system requirements, but also from the standpoint of trade-off factors such as reliability, maintainability, cost, and personnel. Through such early assessment of manpower implications in design, the issues of manpower, training, associated costs, and personnel availability can be addressed in time to benefit program development and implementation.

s. Operational Systems Safety

The principal objective of a system safety program within DOD is to ensure that safety, consistent with mission requirements, is designed into systems, subsystems, equipment, and facilities. Systems safety is the optimum degree of safety within the constraints of operational effectiveness, time, and cost attained through specific application of system safety management and engineering principles whereby hazards are identified, eliminated, and controlled to minimize risks throughout all phases of the system life cycle. An in-house system safety management and engineering capability is necessary to tailor a system safety program for each development program that will satisfy the planning, analyses, reporting and documentation requirements of MIL-STD-882A.

t. Examples of Special Areas of Technology

The following are but three examples of the kinds of technology that require an in-house capability to perform or manage the work done for DOD.

(1) Medical R&D

The Department of Defense must be prepared to defend U.S. national interests worldwide. The medical research program of DOD supports this obligation, based on three premises: first, disease is the leading cause of mandays lost from combat in every war in history; second, wounds are the leading cause of death in combat; and third, modern military weapons systems often approach the human operator's limits to tolerate them. Thus, to conserve human life, DOD's most precious resource, the medical research program aims at prevention of infectious disease, care of the combat wounded, and prevention of the health- and performance-detrimental effects of military systems.

Much of the capability to perform the needed medical research appropriately resides in-house. During wartime the special kinds of expertise associated with disease and hazard prevention and casualty care must be rapidly deployed. The medical research establishment of DOD provides a ready mobilization base for medical support of combat operations. In order for the medical departments to maintain combat readiness, they need a continuing supply of appropriately experienced technical manpower. In peace time, the appropriate experience comes from the medical research program. The military medical research system maintains pools of expertise not found in civilian medical establishments. Thus, in-house medical R&D maintains DOD's medical readiness for combat. In addition, the military medical research community has unique access to weapons systems developers. No other medical community deals with the military impact of human physiological limitations.

(2) Manufacturing Technology

Manufacturing Technology is a DOD program to promote the development and improvement of manufacturing processes, methods, techniques, or equipment which, when applied to production, would reduce the cost of defense material and/or weapon systems. It is an investigative engineering activity to establish innovative and efficient manufacturing methods to produce weapons systems at an affordable cost.

The Manufacturing Technology Program is more suitably managed and administered by a DOD activity than by a contractor because:

(a) A conflict-of-interest situation is less likely to arise in a government-operated program than in one directed by the profit-motivated private sector.

(b) In-house activities have a better understanding of the needs of the military forces, based on long term experience. They are capable of making more valid trade-off assessments, and their flexibility to respond would not be affected by the terms of a contract.

(c) The Manufacturing Technology Program requires a relatively long time from project initiation to realization of profitable results. In-house management and administration provide the stability necessary for such a program.

(3) Environmental Assessment

The weapon systems of the Department of Defense must be designed to work effectively in the real world. The natural environment (weather, ocean conditions, outer space, terrain situations) must be considered in all phases of the life cycle of a weapon system. DOD must have the capability to properly consider the environment in the early design stage, measure the environment during the critical test and evaluation stage, and use accurate and reliable environmental information during the military employment of the resulting system.

DOD maintains a vigorous in-house capability to effect the proper application of environmental knowledge unique to military requirements.